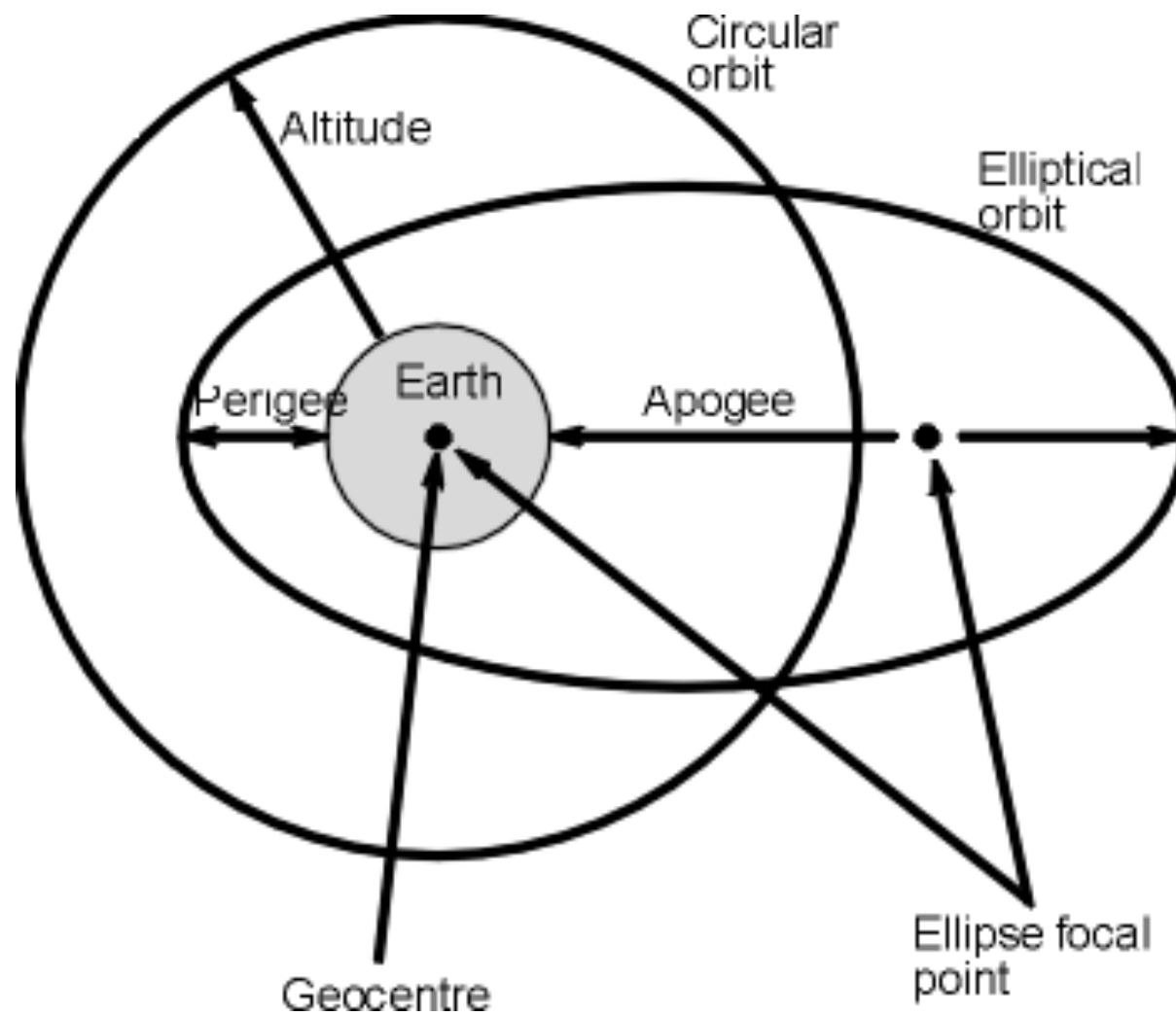


# Orbits



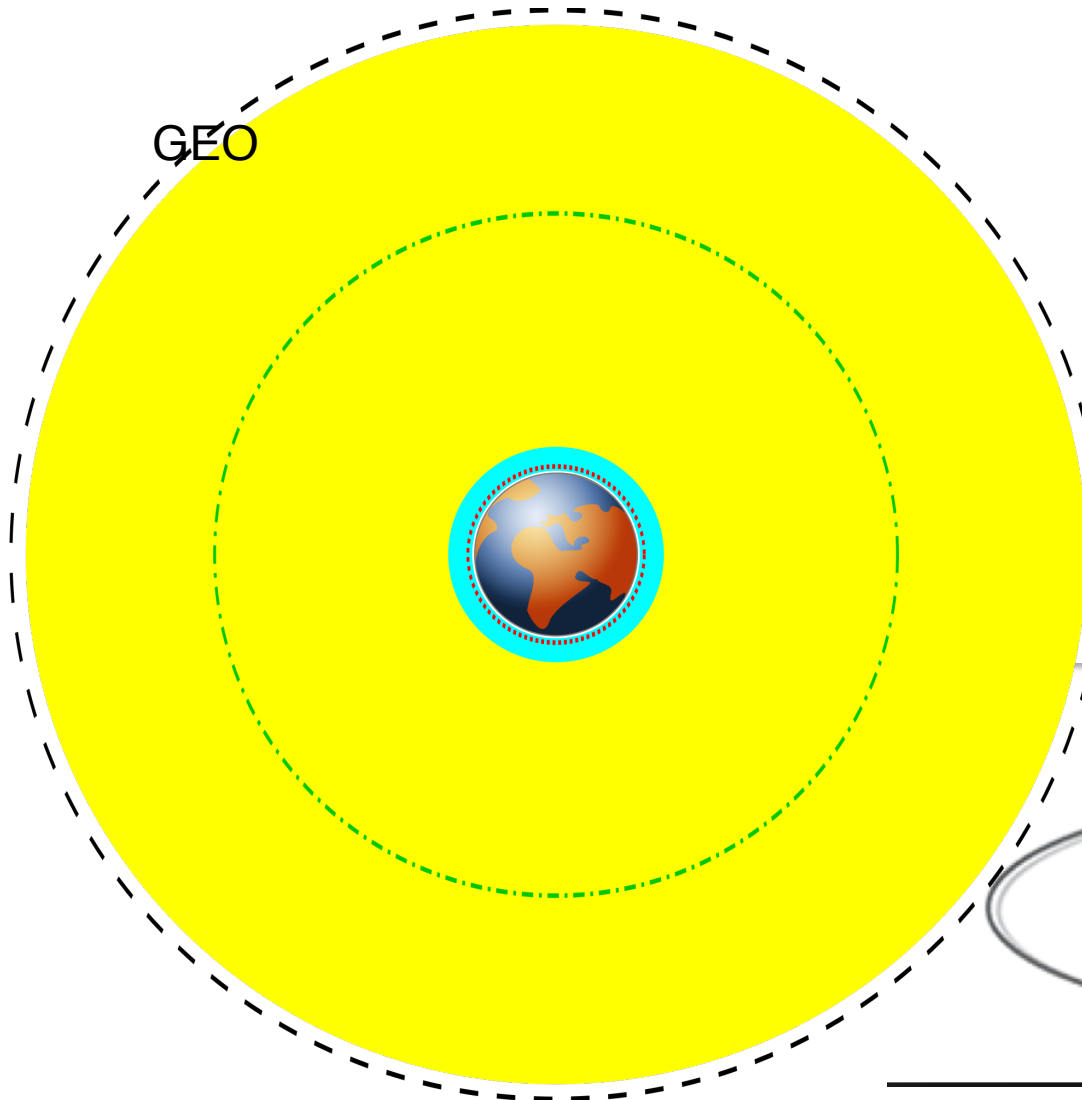
# Orbits

LEO = Low Earth Orbit (100 – 1,500 km)

MEO = Medium Earth Orbit (5,000 – 10,000 km)

GEO = Geostationary Orbit (36,000 km)

HEO = Highly Elliptical Orbit

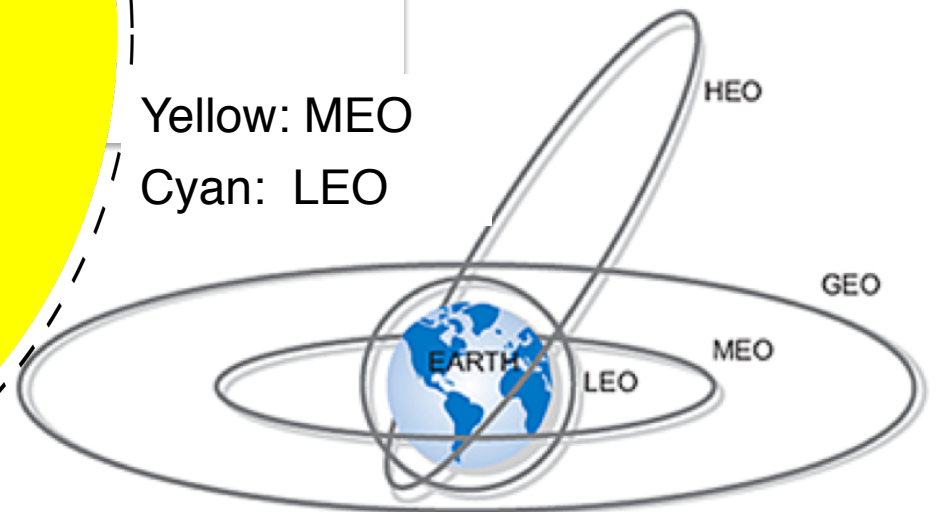


Red dotted line: International Space Station

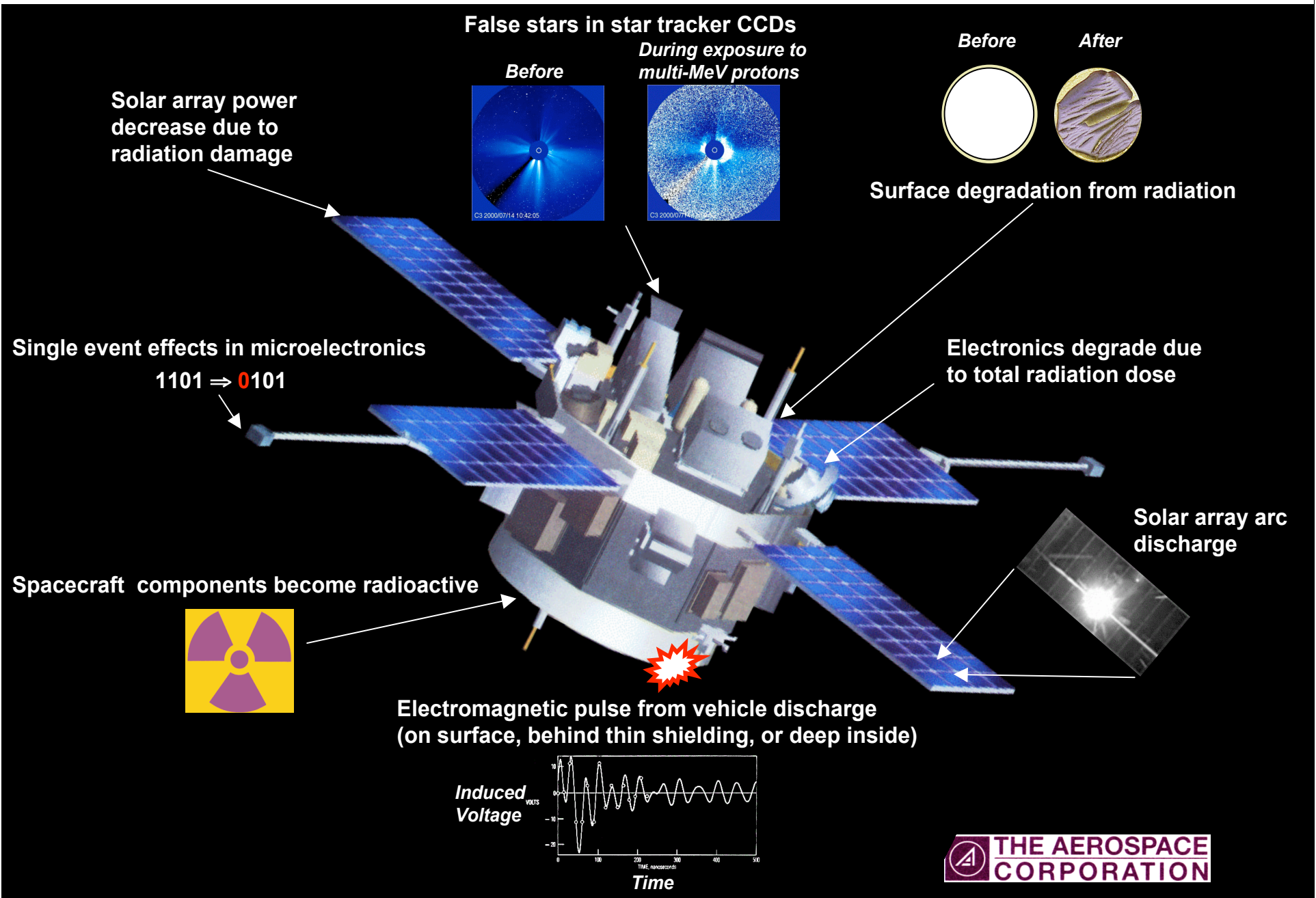
Green-dash-dotted line: GPS

Yellow: MEO

Cyan: LEO



# Visual Representation of Space Environment Hazards



# Seven Types on Space Weather Impacts for NASA's Robotic Missions

1. **Spacecraft surface charging caused by low-energy ( $< 100$  keV) electrons**, which are abundant, for example, in the inner magnetosphere during magnetospheric substorms.
2. **Spacecraft internal electrostatic discharge caused by high-energy electrons ( $> 100$  keV)** that exist, for example, in the dynamic outer radiation belt of the Earth.
3. **Single event effects due to high-energy ( $> 10$  MeV) protons and heavier ions** generated, for example, in solar flares and in coronal mass ejection (CME) shock fronts.
4. **Total dosage effects caused by cumulative charged particle radiation** received by spacecraft.
5. **Increased spacecraft drag caused by the thermal expansion of the Earth's upper atmosphere** during space weather storms.
6. **Communication disruptions between ground stations and spacecraft** due to ionospheric irregularities
7. **Attitude control disruptions caused, for example, by large storm-time magnetic field fluctuations** in the geostationary orbit.

# Space Environment Effects

Mechanism	Effect	Source
<b>Surface Charging</b>	<ul style="list-style-type: none"> <li>• Biasing of instrument readings</li> <li>• Power drains</li> <li>• Physical damage</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Dense, cold plasma</i></li> <li>• <i>Hot plasma</i></li> </ul>
<b>Deep Dielectric Charging</b>	<ul style="list-style-type: none"> <li>• Biasing of instrument readings</li> <li>• Electrical discharges causing physical damage</li> </ul>	<ul style="list-style-type: none"> <li>• <i>High-energy electrons</i></li> </ul>
<b>Structure Impacts</b>	<ul style="list-style-type: none"> <li>• Structural damage</li> <li>• Decompression</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Micrometeoroids</i></li> <li>• <i>Orbital debris</i></li> </ul>
<b>Drag</b>	<ul style="list-style-type: none"> <li>• Torques</li> <li>• Orbital decay</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Neutral thermosphere</i></li> </ul>
<b>Total Ionizing Dose (TID)</b>	<ul style="list-style-type: none"> <li>• Degradation of microelectronics</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Trapped protons</i></li> <li>• <i>Trapped electrons</i></li> <li>• <i>Solar protons</i></li> </ul>
<b>Displacement Damage Dose (DDD)</b>	<ul style="list-style-type: none"> <li>• Degradation of optical components and some electronics</li> <li>• Degradation of solar cells</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Trapped protons &amp; electrons</i></li> <li>• <i>Solar protons</i></li> <li>• <i>Neutrons</i></li> </ul>
<b>Single-Event Effects (SEE)</b>	<ul style="list-style-type: none"> <li>• Data corruption</li> <li>• Noise on images</li> <li>• System shutdowns</li> <li>• Electronic component damage</li> </ul>	<ul style="list-style-type: none"> <li>• <i>GCR heavy ions</i></li> <li>• <i>Solar protons and heavy ions</i></li> <li>• <i>Trapped protons</i></li> <li>• <i>Neutrons</i></li> </ul>
<b>Surface Erosion</b>	<ul style="list-style-type: none"> <li>• Degradation of thermal, electrical, optical properties</li> <li>• Degradation of structural integrity</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Particle radiation</i></li> <li>• <i>Ultraviolet</i></li> <li>• <i>Atomic oxygen</i></li> <li>• <i>Micrometeoroids Contamination</i></li> </ul>